High-Purity Telecom-Band Entangled Photon-Pairs via Four-Wave Mixing in Dispersion-Shifted Fiber

Kim Fook Lee, Jun Chen, Chuang Liang, Xiaoying Li, Paul L. Voss, and Prem Kumar

Center for Photonic Communication and Computing, EECS Department, Northwestern University, 2145 Sheridan Road, Evanston, IL, 60208-3118, USA
kflee@ece.northwestern.edu

Abstract: We have studied the purity of entangled photon-pairs generated in a dispersion-shifted fiber at various temperatures. Two-photon interference with visibility > 98% is observed at 77K, without subtraction of the background Raman photons.

OCIS codes: (270.0270) Quantum optics; (190.4370) Nonlinear optics, fibers.

For many quantum information processing applications it is desirable to produce entangled photon-pairs at telecom wavelengths directly in the fiber by use of the fiber's Kerr nonlinearity. Our previous works [1] have pointed out that spontaneous Raman scattering, which gives rise to majority of background photons, prevents one from achieving two-photon interference with unit visibility. In this paper we report on measurements of true coincident counts due to correlated photon-pairs and accidental coincident counts due to the background Raman photons in a dispersion-shifted fiber (DSF) at various temperatures (room, 300 K; dry ice, 195 K; and liquid nitrogen, 77 K). Figure 1(a) depicts our experimental setup. Pump pulses of $\tau_p \simeq 6$ ps duration and $\lambda_p = 1538.7$ nm wavelength arrive at 75.3 MHz rate. A 300m piece of DSF with $\lambda_0 = 1538.7$ nm is used. The signal (idler) photons of 1543.5 nm (1533.9 nm) wavelength are detected with total detection efficiency of 9% (7%). With the uncooled and cooled fibers we record coincidence and accidental-coincidence counts for varying pump powers. After subtracting dark counts of detectors we plot the ratio between coincidence and accidental-coincidence counts vs. single counts/pulse as shown in Fig. 1(b). Ratios as high as 111:1 at 77 K (60:1 at 195 K) are obtained compared to 28:1 at room temperature. At 77 K, the maximum ratio is obtained for $\simeq 75\,\mu$W of pump power, corresponding to signal-idler photon-pair production rate of $\simeq 0.01$/pulse.

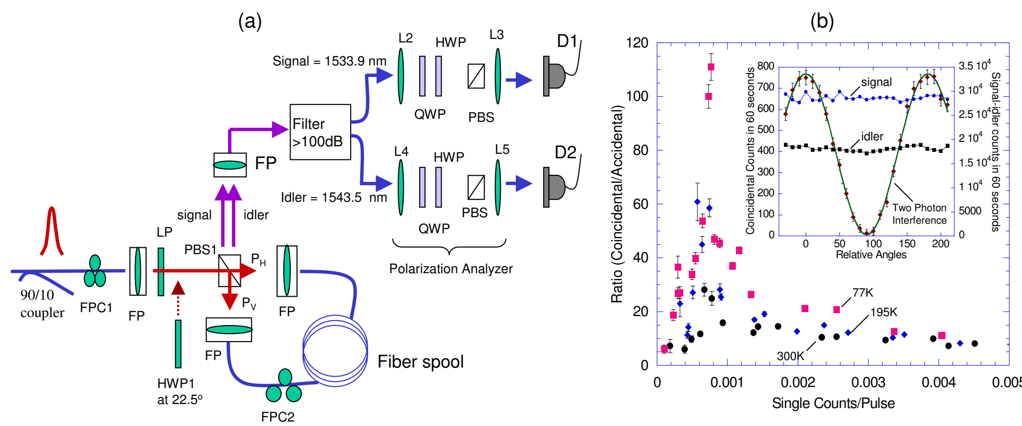

Fig. 1. (a) Experimental Setup. (b) Experimental Results.

A horizontally-polarized pump pulse is split into P_H and P_V by the half-wave plate (HWP1) placed in front of a polarization beam splitter (PBS1). The clockwise and counter-clockwise pump pulses scatter signal-idler photon-pairs, which are then coherently superimposed through the same PBS1, thus creating the two-photon polarization-entangled state $|H_i\rangle|H_s\rangle + |V_i\rangle|V_s\rangle$ at the output of PBS1. We record two-photon coincidence counts while varying the relative polarization angles of signal and idler channels. At 77 K we observe two-photon interference with visibility > 98% without subtraction of the accidental counts caused by the background Raman photons, as shown in the inset of Fig. 1(b). The observed high visibility is attributed to the suppression of spontaneous Raman scattering at lower temperatures. The observed visibility is about 95% (91%) at 195 K (300 K). This work is supported in part by the NSF under Grant No. EMT- 0523975.

References

1. X. Li, P. L. Voss, J. E. Sharping, and P. Kumar, Phys. Rev. Lett. **94**, 053601 (2005); X. Li, P. L. Voss, J. Chen, J. E. Sharping, and P. Kumar, Opt. Lett. **30**, 1201 (2005).